DIS Event shape (1-jettiness) studies for EIC YR

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EIC Jets & HF Working Group Meeting

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In collaboration with
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Peter Jacobs (LBNL)
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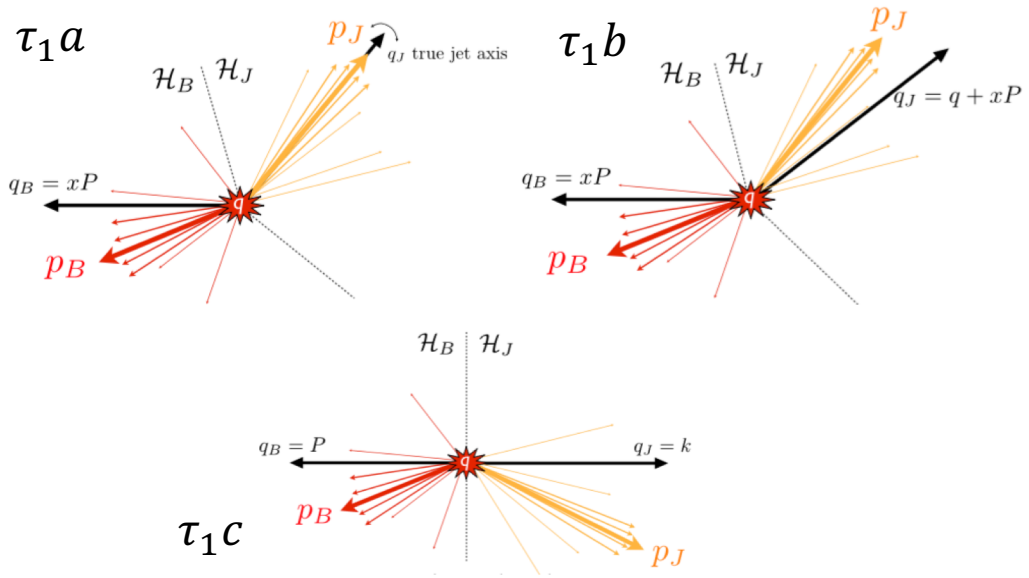
1-jettiness



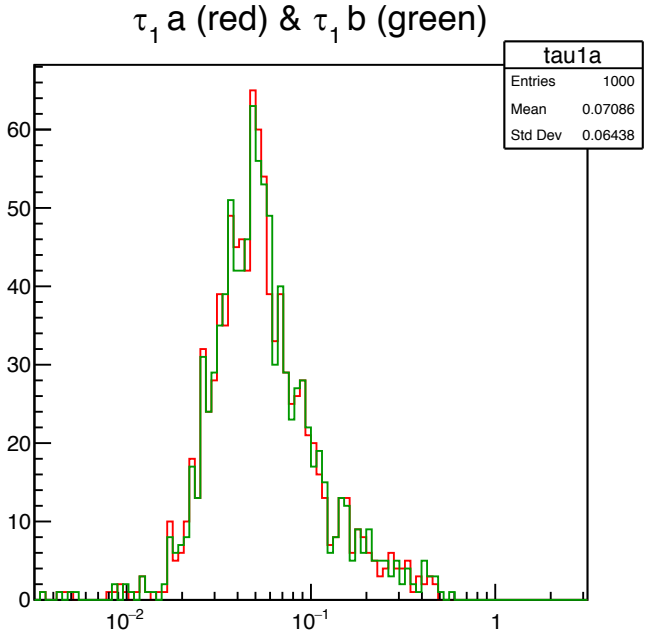
$$\tau_1 = \frac{2}{Q^2} \sum_{i \in X} \min\{q_B \cdot p_i, q_J \cdot p_i\}$$

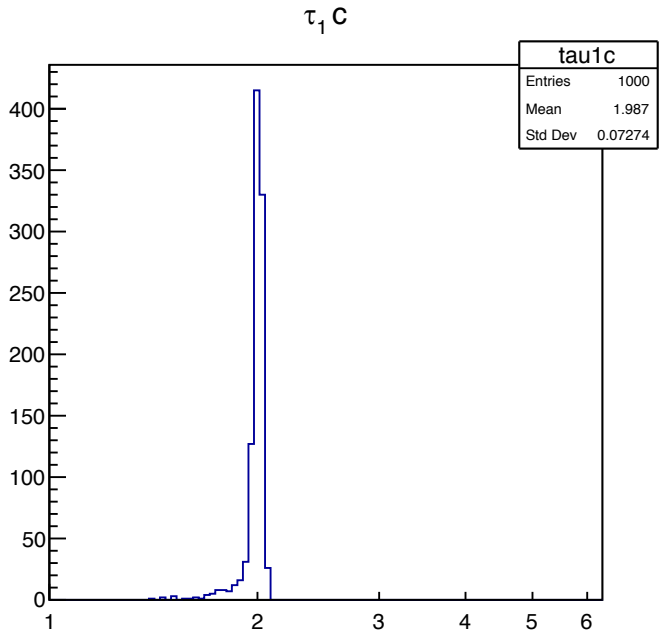
A global shape measuring degree to which final state is 1-jet (+ beam ISR jet) - like.

Motivation:
N^{3}LL ressummed high precision prediction expected in theory; if similar precision achievable experimentally, can measure running of α_s down to low Q^2

- Past presentations:
  - by Christopher Lee https://indico.bnl.gov/event/8238/contributions/36464/attachments/27517/421 05/EICUG_2020_Apr_06.pdf
  - by Leticia Cunqueiro https://indico.bnl.gov/event/8494/contributions/37481/attachments/28026/43014/1-jettiness_at_the_EIC.pdf

3 versions of 1 jettiness at x=0.5, Q=50 GeV, E_p =275 GeV, E_e= 18 GeV (Truth)





$\tau_1 a$: ‘A’ligned with jet axis.

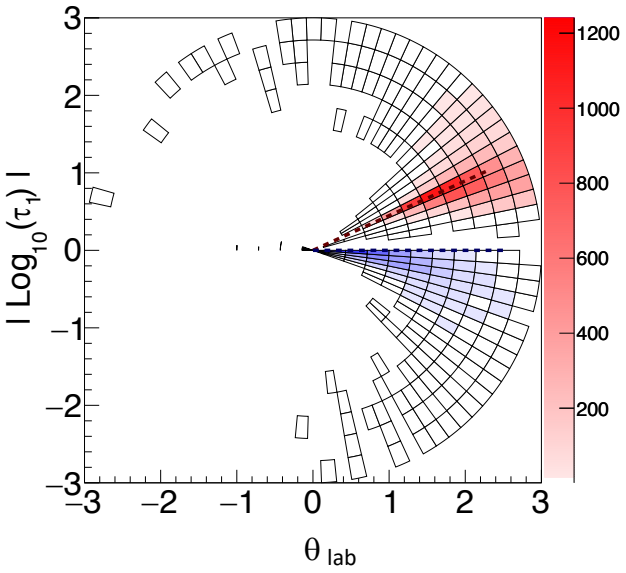
$\tau_1 b$: ‘B’reit frame.

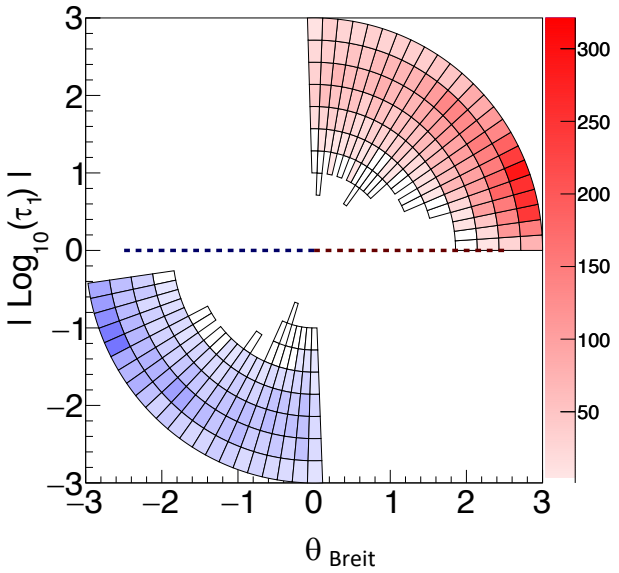
$\tau_1 c$: ‘C’M frame.

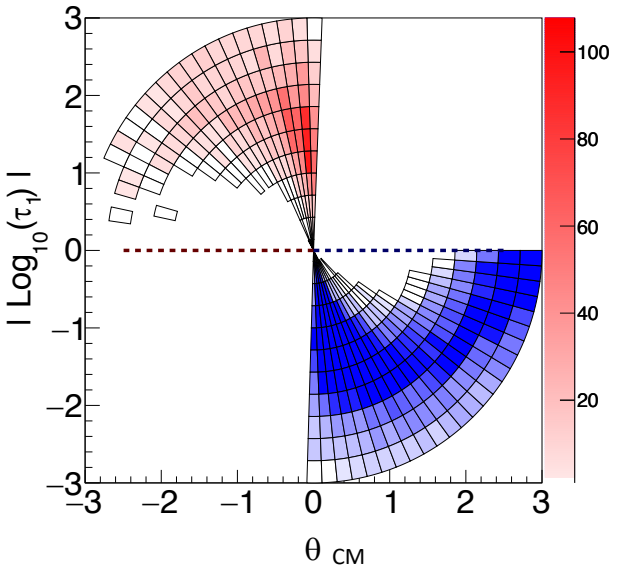
Distributions of constituent particles in $\tau - \theta$ space

at x=0.5, Q=50 GeV,

E_p =275 GeV, E_e= 18 GeV (Truth)







Red: $\tau_{1\,\mathrm{J}}$

Blue: $\tau_{1\,\mathrm{B}}$

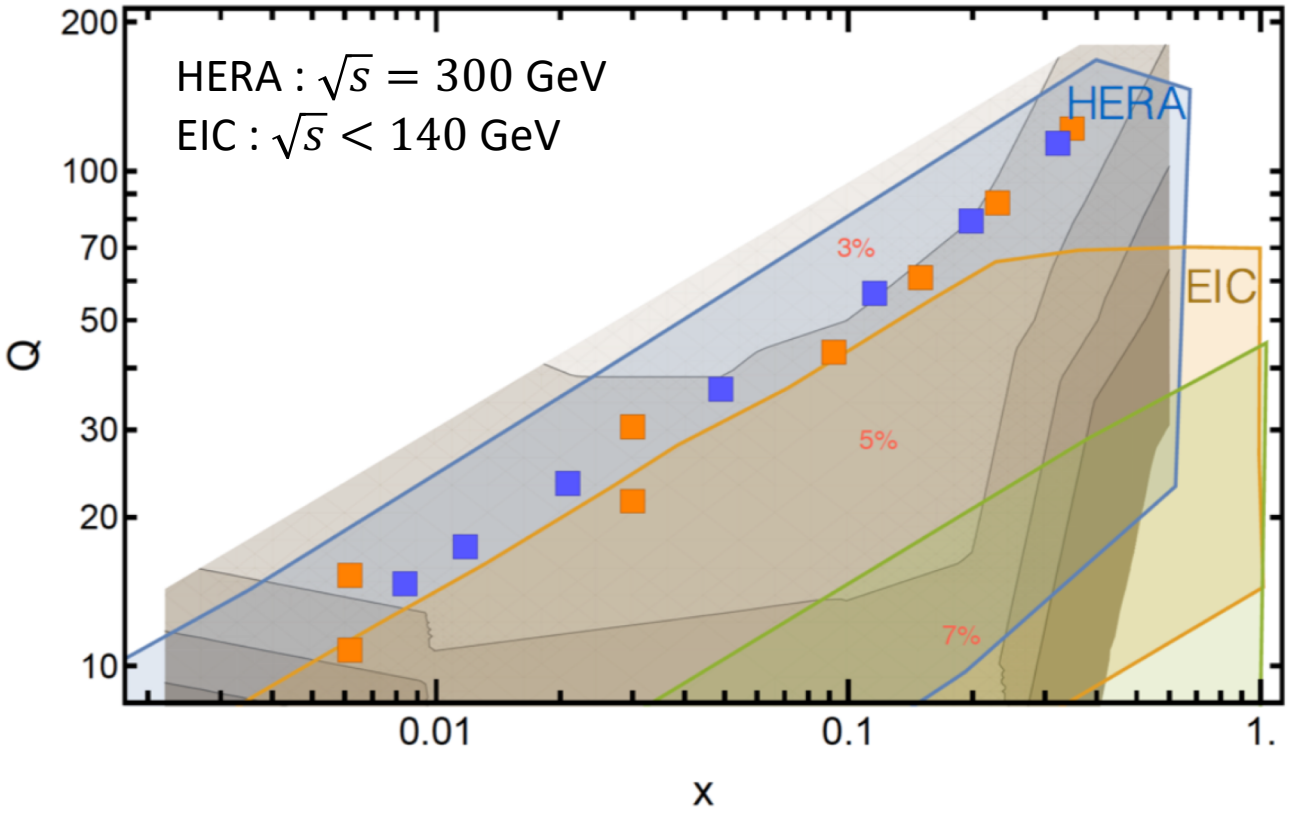
Considerations for YR detector requirements

- 0^{th} order considerations are :
  - Kinematic reach ✓
  - Statistics limited by luminosity ✓
  - Theoretical uncertainties: WIP by Daekyoung/Chris
- 1^{st} order – define performance criteria for observables
  - x & Q^2 resolutions ✓
  - τ_1 resolution ✓
  - Missing particle suppression factors ✓
- 2^{nd} order – distortions in tau measurements :
  - Default EIC smear ✓
  - Hadronic calorimeter resolution: energy and position of hadrons
  - Particle identification, tracking
  - Modes of measurements
  - Exploration of unfolding to correct smearing due to various resolution factors

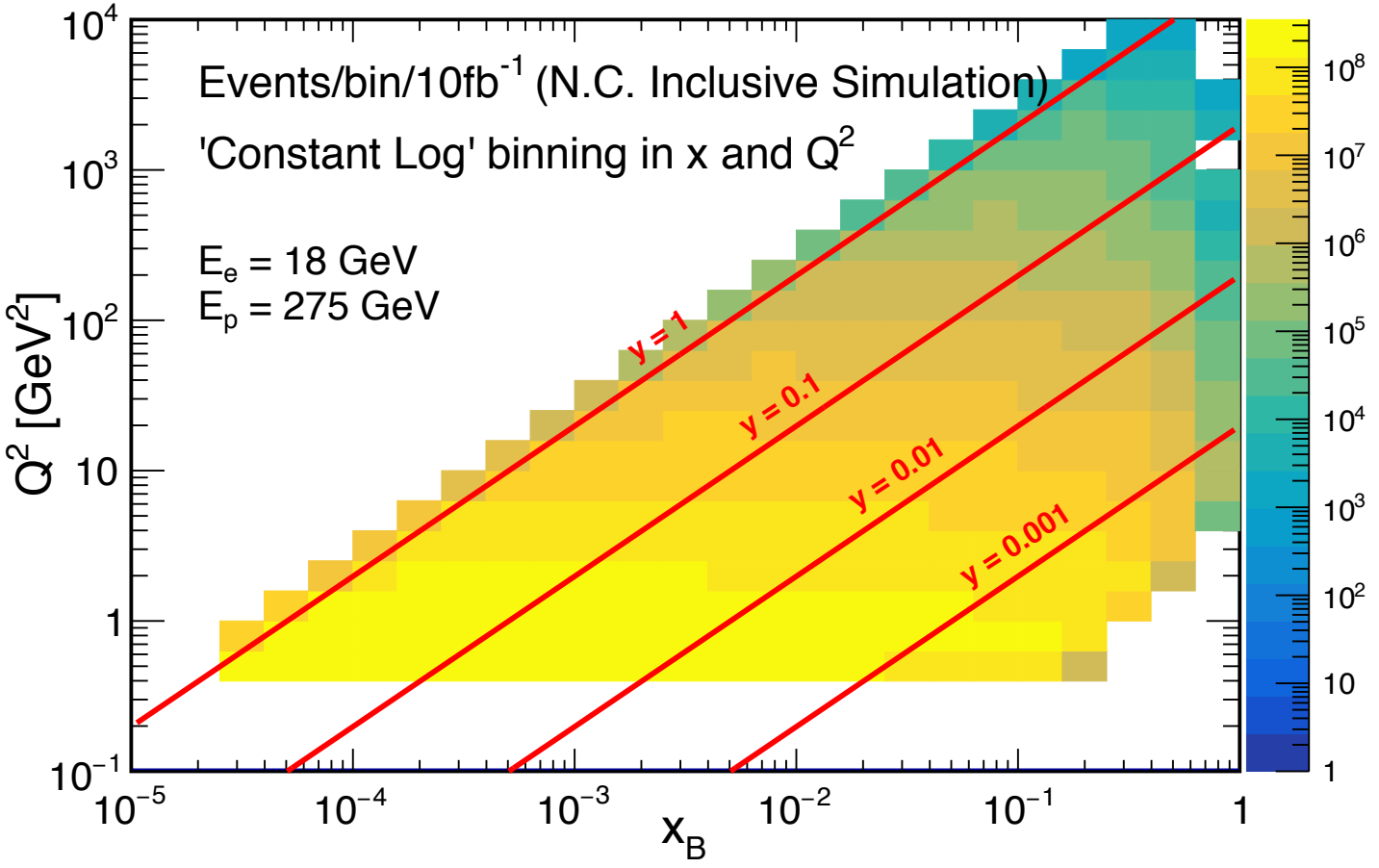
Theoretical precision in Q^2 vs. x phase space

Current theoretical uncertainty vs. HERA or EIC coverage:

From Chris's presentation in April
(Updated predictions WIP)



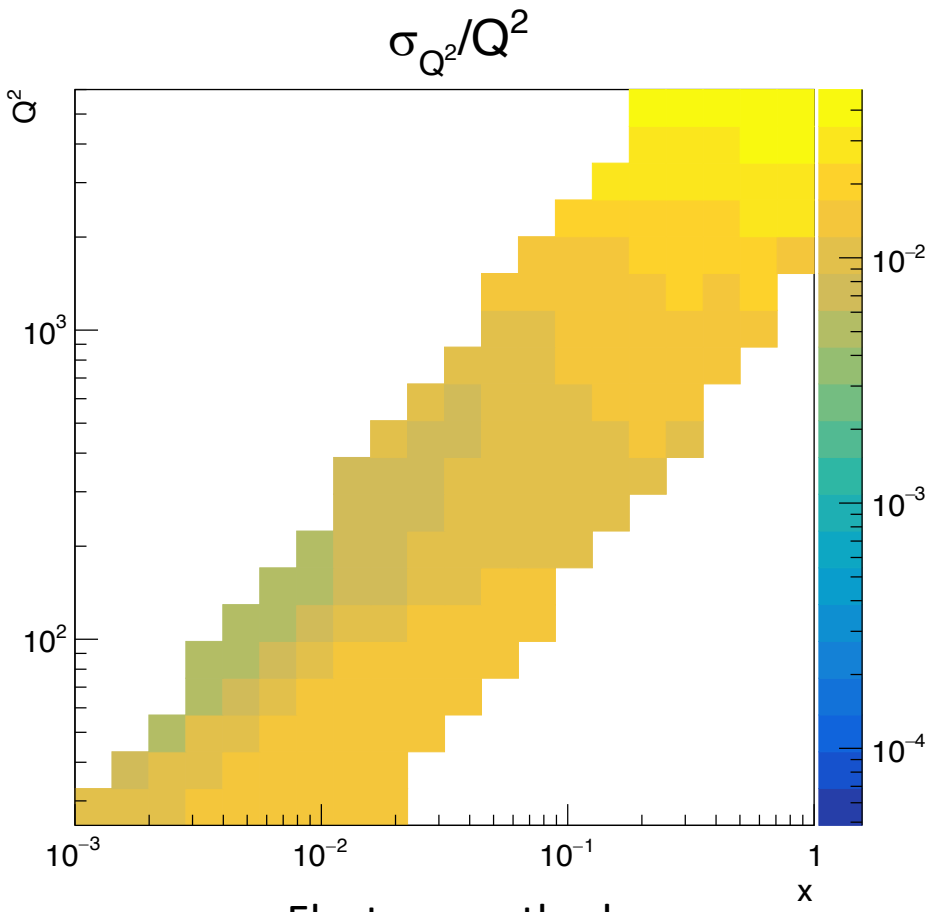
Kinematic reach for EIC



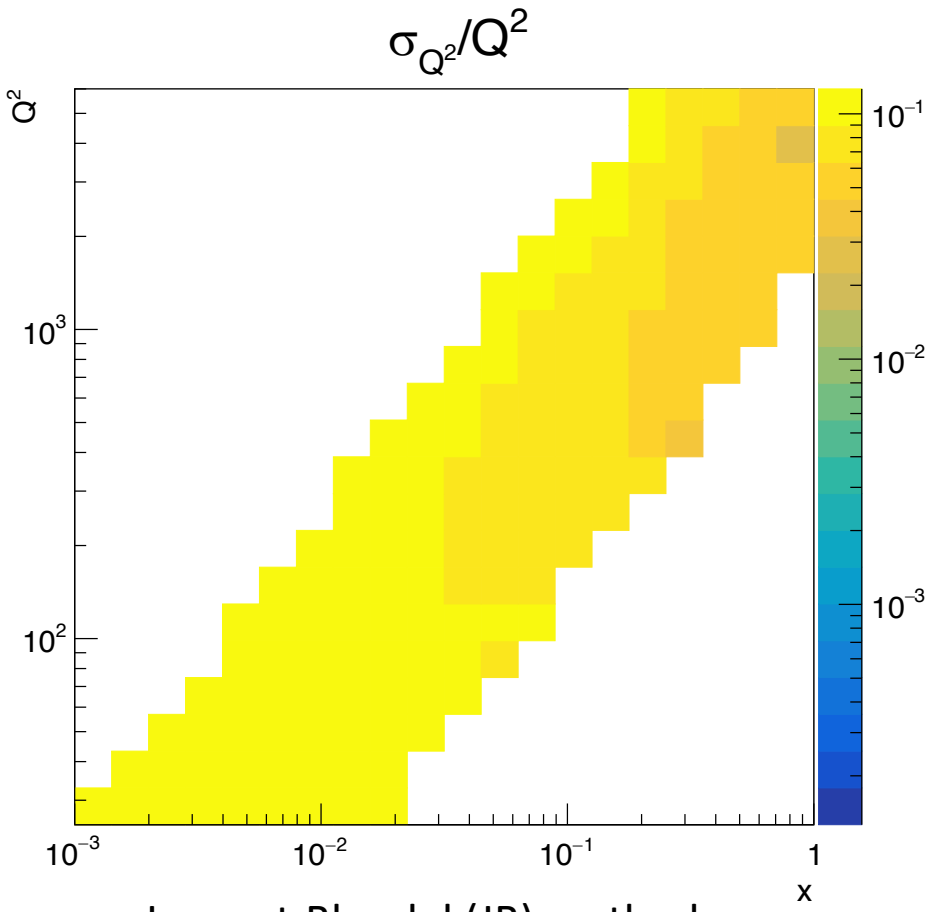
Courtesy of Barak Schmookler

Q^2 resolutions (EIC Smear)

- Event cuts: $y > 0.1$, $Q^2 > 25\ GeV^2$



Electron method

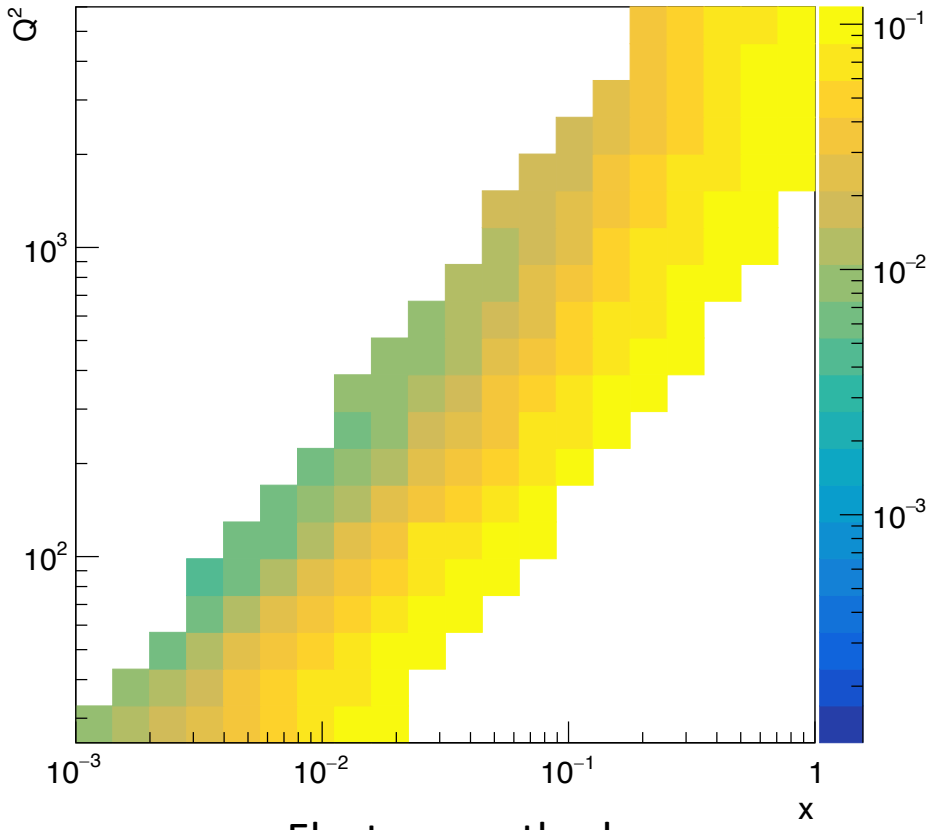


Jacquet-Blondel (JB) method

x resolutions (EIC Smear)

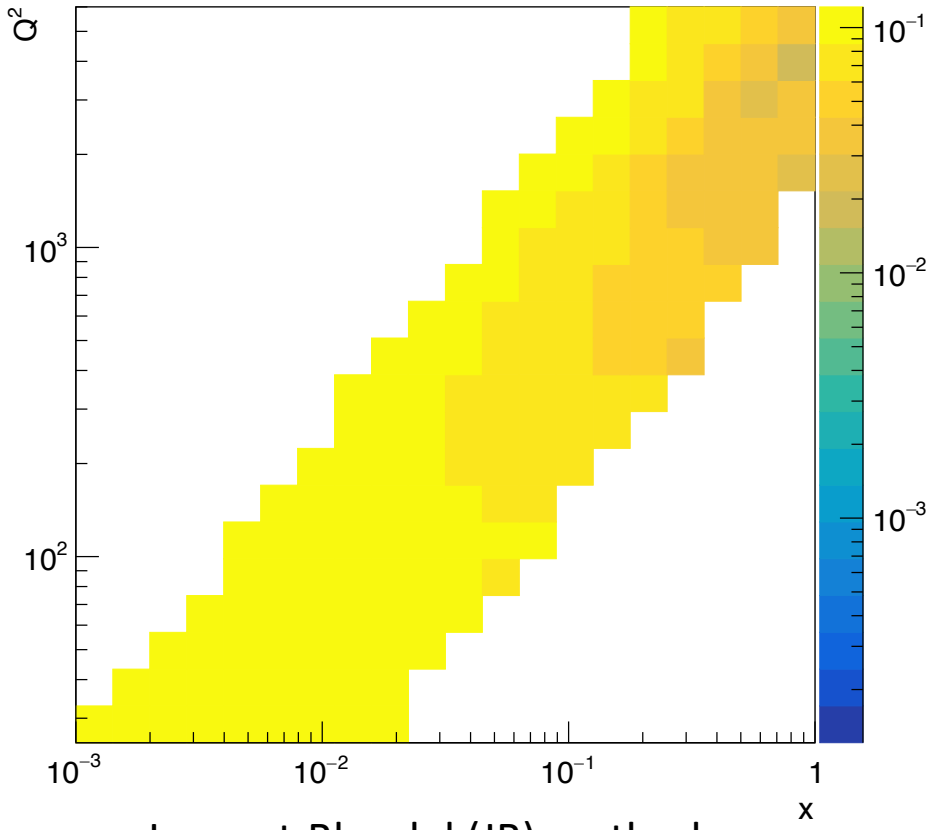
- Event cuts: $y > 0.1$, $Q^2 > 25\ GeV^2$

σ_x/x



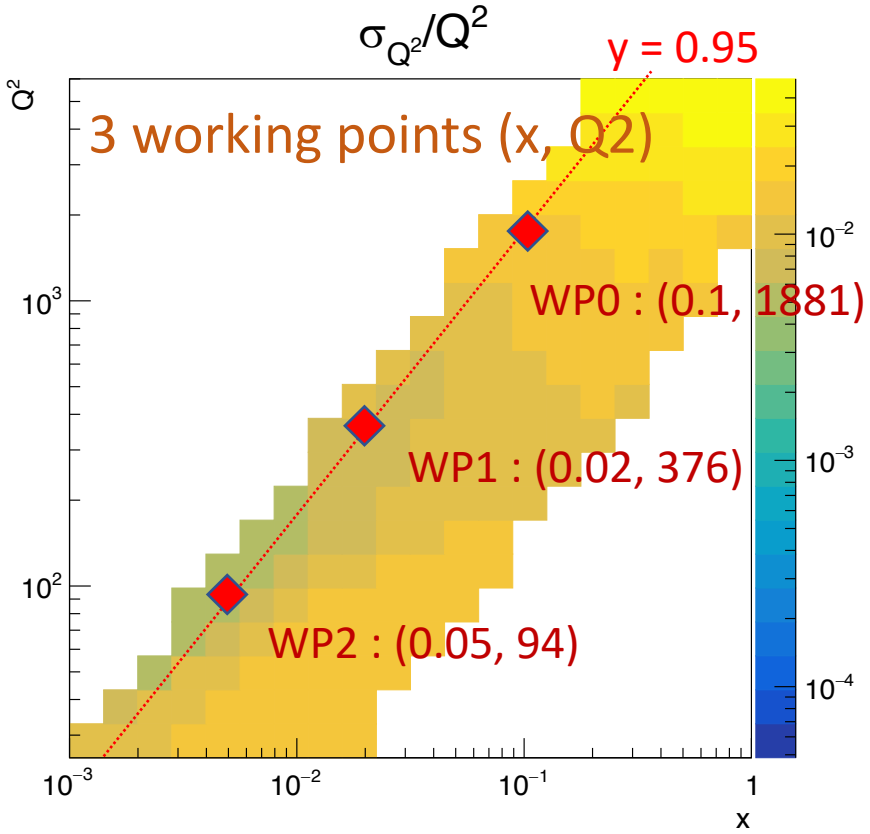
Electron method

σ_x/x

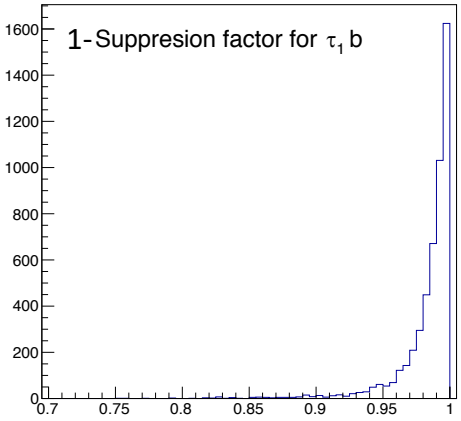


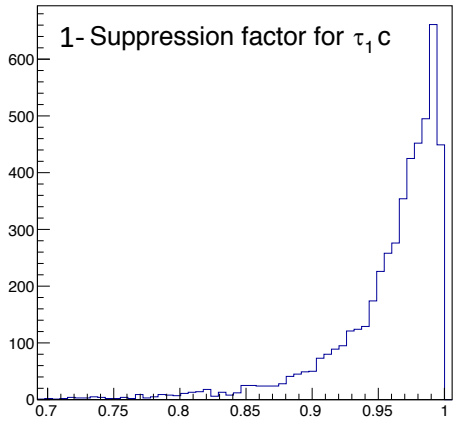
Jacquet-Blondel (JB) method

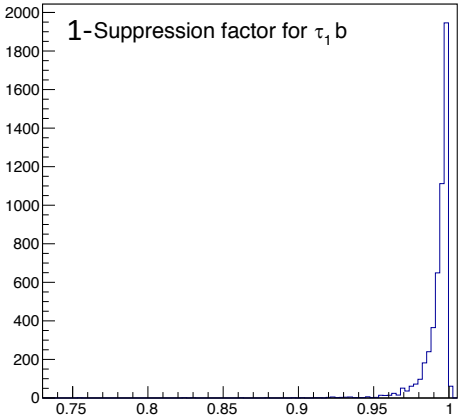
Missing particle suppression factors (no smear)

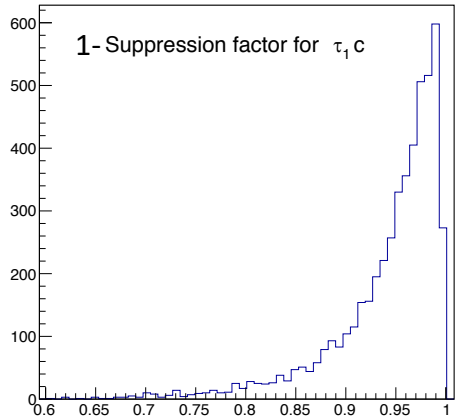


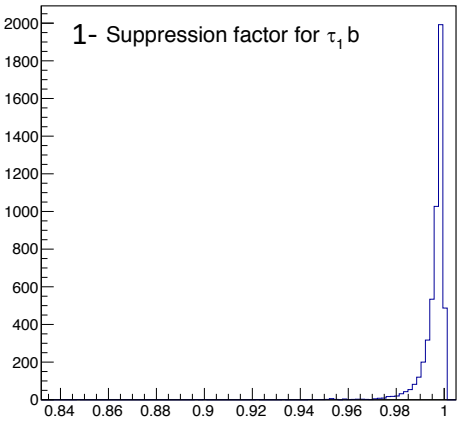
- Defined by loss of τ caused by requiring $|\eta|$ <3.5.
- Will look how much things get better/worse as η cut changes.

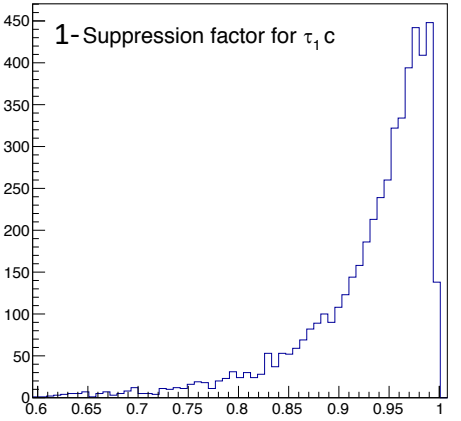




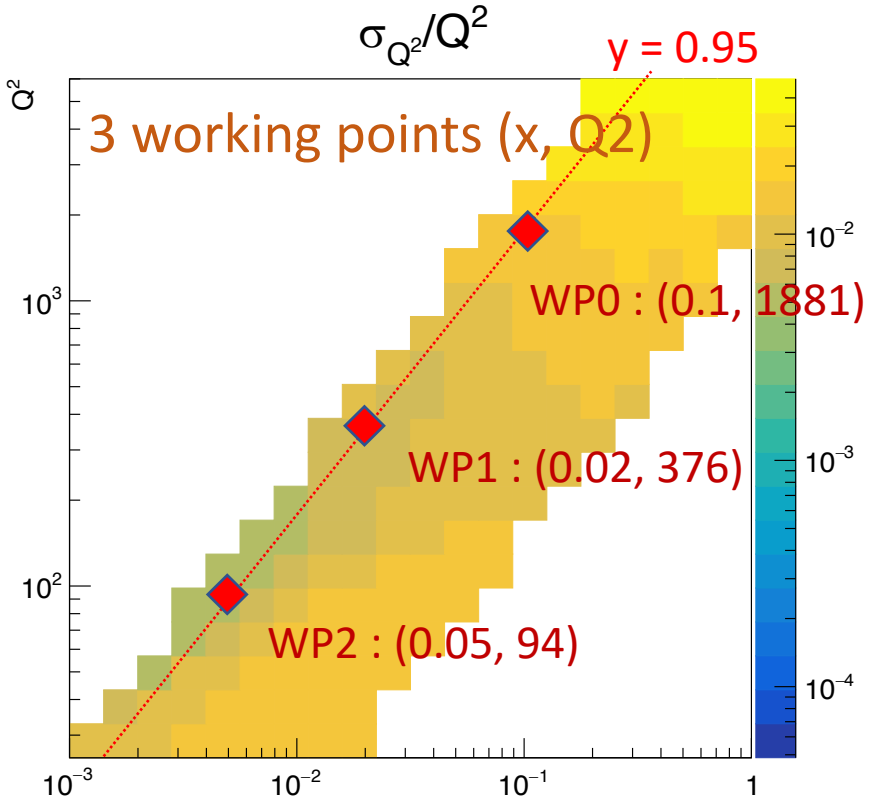


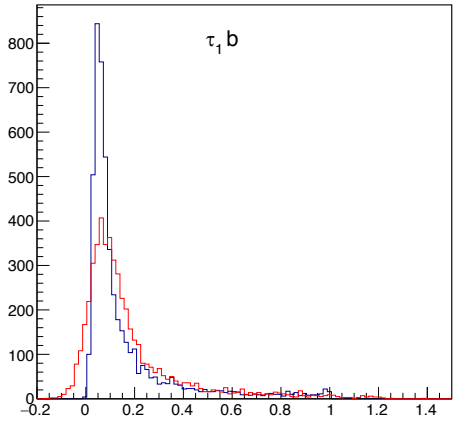


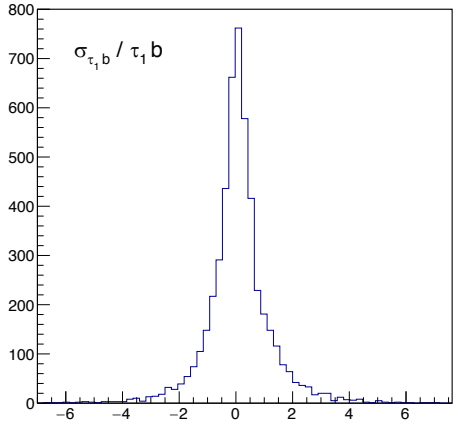


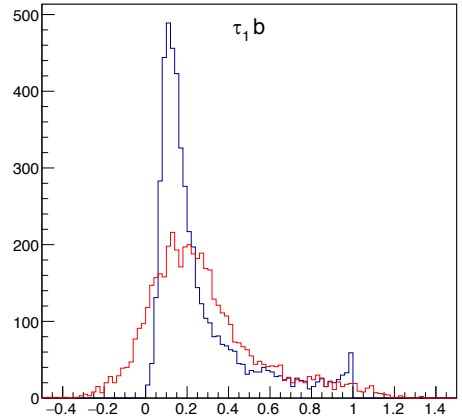


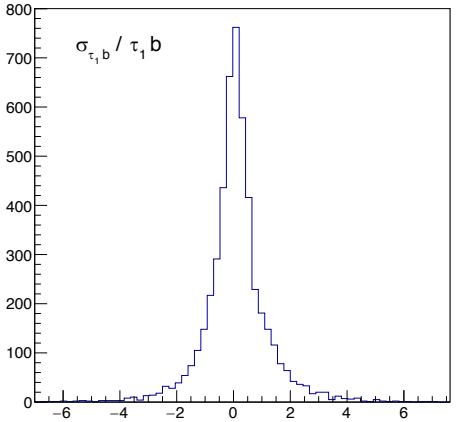
τ_{1b} resolution (EIC Smear, Perfect PID)

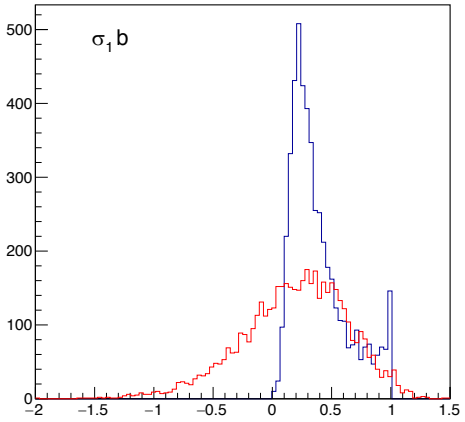


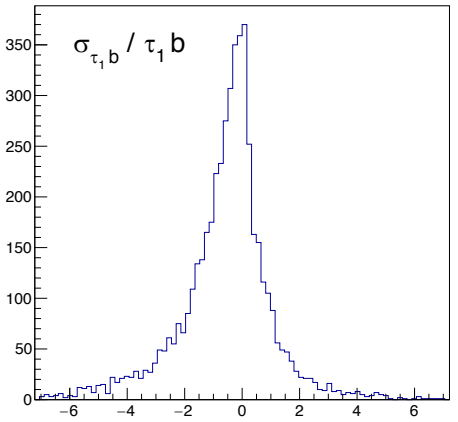












- Smearing worsens with decreasing Q^2.
- Explore unfolding for improvement.
- Need to work out budget for energy, momentum & position resolutions for various detectors.

Summary & Plans

- Basic DIS kinematics studies for 1-jettiness measurements completed.
- Define key detector requirements to be able reach theoretical sweet spot in Q^2-x phase space.
- Assess effects of detector imperfectness:
  - PID
  - Low momentum cutoff & tracking limitation
  - Explore different modes of measurment (track-only, track+EMCAL, track+EMCAL+HCAL)
  - Explore unfolding to correct smearing due to various resolution factors